E 1.28: SOLAR/2019-79/06

SOLAR/2019-79/06

Monthly Performance Report

SOUTH DAKOTA SCHOOL OF MINES

JUNE 1979

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U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

4294

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MONTHLY PERFORMANCE REPORT
SOUTH DAKOTA SCHOOL OF MINES
JUNE 1979

I. SYSTEM DESCRIPTION

The South Dakota School of Mines solar energy system is installed in the visitors' center of the Mount Rushmore National Memorial at Keystone, South Dakota. The solar energy system is a retrofit to the original heating and cooling system, and is designed to provide 45 percent of the annual heating requirements for the entire building and provide 53 percent of the annual air conditioning requirements for the observation room.

Solar energy collection is performed by 112 double-glazed, flat-plate collectors manufactured by Lennox Industries, Inc., that have a gross area of 2,000 square feet. The collectors are mounted in six arrays on the roof of the building, and face 19 degrees west of south with a tilt of 46 degrees from the horizontal. The main system loop contains 150 gallons of 50 percent ethylene glycol and water solution, which is used to transfer energy, as required, from the collector to the collector-to-storage heat exchanger, the collector-to-space heating heat exchanger, and absorption chillers. Thermal storage is provided by 3,000 gallons of water in a steel storage tank that is insulated with three inches of fiberglass.

Heating demands are met by transferring energy from the collector, or storage, to heating coils in the building multizone air handler. The multizone fan is energized continuously to circulate building air, and dampers in the multizone unit are positioned to allow flow across the solar heating coil when the system is in a solar heating mode. Auxiliary heating is provided by a two-stage fuel oil furnace.

Thermal energy from the collectors is used to operate three absorption chillers; chilled water from these chillers is circulated through a cooling coil in the observation room air handler. Thermal energy from storage is

not used to operate the chillers because of temperature limitations. Auxiliary cooling is provided to both the multizone and single-zone air handlers by vapor compression units.

This system, which is shown schematically in Figure 1, has six modes of solar operation.

Mode 1 - Solar Energy Collection: The solar collection mode is entered when the collector absorber plate temperature is greater than 100°F. In this mode, pump P1 is energized and valve V4 is positioned to allow flow through the collectors. This mode is entered even though there is no heating or cooling load and storage tank charging criteria have not been met. This mode continues until the collector plate temperature is less than 100°F; however, an adjustable time-delay circuit delays pump P1 shutdown to prevent short cycling.

Mode 2 - First Stage Heating From Collectors: This mode is entered when the system is in the collection mode and a demand for heat is determined by the difference between the conditioned space thermostat setting and the discharge air temperature in the multizone air handler. In this mode, valve V7 is positioned to allow flow through the heating coil HX2 located in the multizone air handler, and valve V5 is positioned to bypass the absorption chillers. Flow through the heating coil is provided by pump P1. If the heating demand cannot be met using solar energy, a fuel-oil furnace is used in conjunction with, and independent of, solar heating.

Mode 3 - First Stage Heating From Storage: This mode is entered when there is a heating demand, energy is not available from the collectors, and energy is available from storage because the top tank temperature is greater than 100°F. In this mode, valves V5 and V7 are in the heating positions, and valve V4 is in the collection bypass position. Valves V1 and V2 are positioned to allow flow into the bottom and out of the top of the storage tank. Pump P2 is energized to circulate water between the storage tank and the water side of the storage heat exchanger HX1, and pump P1 is energized to

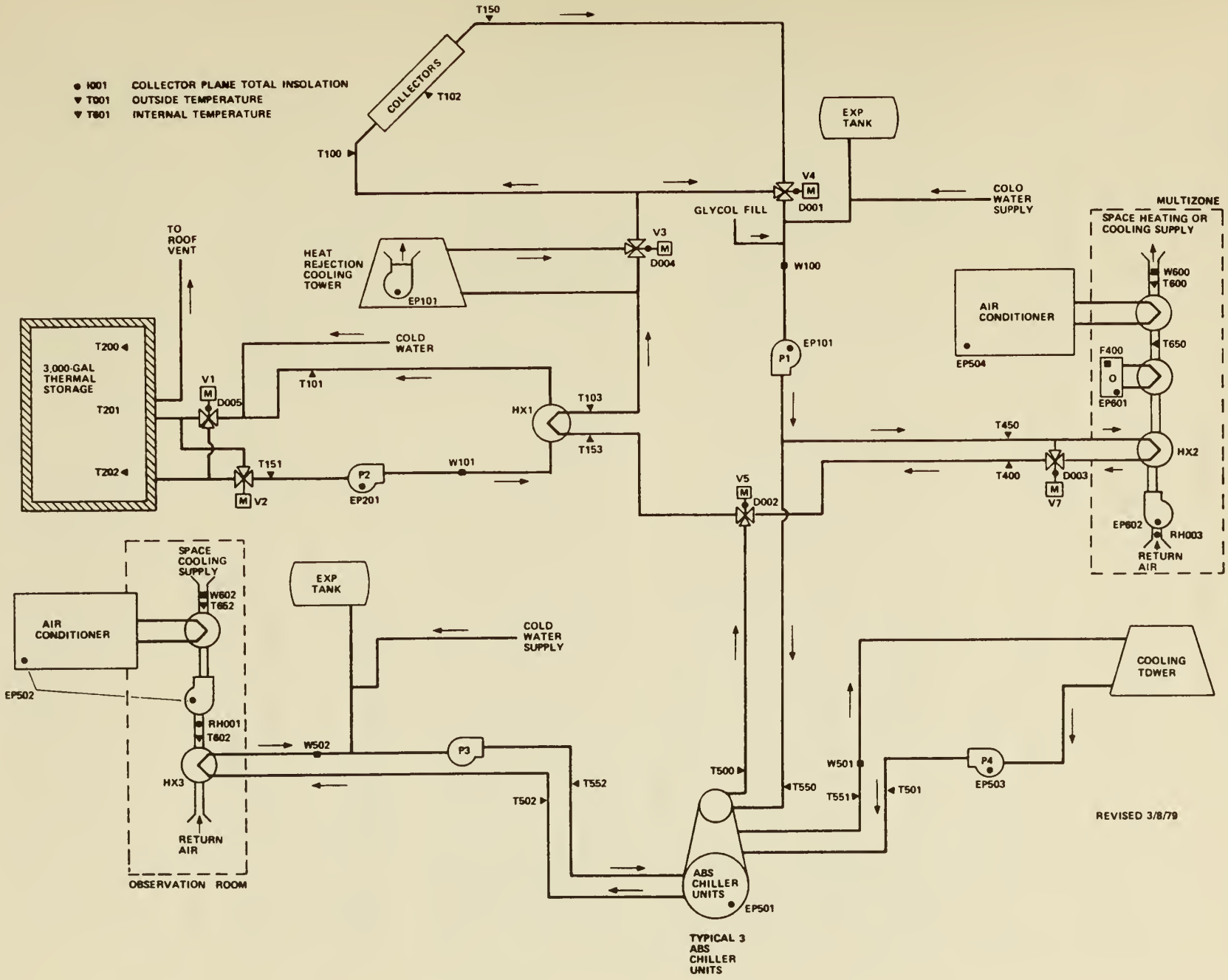

Figure 1. SOUTH DAKOTA SCHOOL OF MINES SOLAR ENERGY SYSTEM SCHEMATIC

circulate the main system fluid between the glycol/water side of exchanger HX1 and the liquid side of heating coil HX2 in the air handler. Multizone air handler and oil furnace operations are the same as described in Mode 2.

Mode 4 - Single-Zone Cooling From Collectors: This mode is entered when sufficient solar energy from the collectors is available, and when a demand for single-zone cooling is determined by the conditioned space thermostat (located in the observation room) and the discharge air temperature of single-zone air handler.

Since generator inlet temperatures of 180°F are required in order to operate the ARKLA absorption chillers, this mode is not allowed until collector outlet temperatures reach this level. If temperature requirements are met, valve V5 is positioned to allow flow through the chillers' generators, provided that pump P3 is operating to circulate chilled water through the solar cooling coils. Pump P4 is energized to circulate condensing water through the cooling tower. The cooling tower fan is controlled by an aquastat to maintain a sump temperature of 85°F.

Safety cutoffs are also provided to prevent either overheating or excessive cooling of the chillers. No solar cooling from the storage mode is provided since maximum storage tank temperature and energy losses prohibit efficient operation of the chillers. Auxiliary cooling will be provided by vapor compression units (A/C unit) in the single-zone and multizone air handlers.

Mode 5 - Storage Tank Charging: This mode is entered when the inlet temperature on the glycol/water side of the storage heat exchanger is 20°F greater than the storage tank bottom temperature. This mode is also entered in the cooling mode if, in addition to being 20°F greater than the storage temperature, the heat exchanger inlet temperature (glycol/water side) is greater than 195°F.

In this mode, valves V1 and V2 are positioned to allow flow into the top and out of the bottom of storage, and pump P2 is energized to circulate water from storage through the heat exchanger. This mode is stopped if storage tank temperatures exceed 205°F.

Mode 6 - Excess Heat Rejection: This mode is entered when the storage heat exchanger outlet temperature (T103) exceeds 205°F. In this mode, valve V3 is positioned to allow flow through the heat rejection cooling tower. The fan in this tower is controlled by an aquastat to maintain a sump temperature of 195°F.

II. PERFORMANCE EVALUATION

The system performance evaluations discussed in this section are based primarily on the analysis of the data presented in the attached computer-generated monthly report. This attached report consists of daily site thermal and energy values for each subsystem, plus environmental data. The performance factors discussed in this report are based upon the definitions contained in NBSIR 76-1137, Thermal Data Requirements and Performance Evaluation Procedures for the National Solar Heating and Cooling Demonstration Program.

A. Introduction

The Mount Rushmore Visitor's Center solar energy system was operational throughout the month of June. However, due to the failure of a signal conditioning module in the SDAS and resultant measurement errors on the first 32 channels, data for the first 15 days was not useable for reporting purposes. This report, therefore, covers only the period from June 15 through June 30, 1979 for which valid data was received. Consequently, the accuracy of the estimated monthly energy values may be significantly less than normal.

During this reporting period, the first cooling operation by the solar energy system for 1979 was observed.

B. Weather

During the last half of June, the measured outside ambient temperature was 62°F which is 2°F below the long-term average for the Rapid City, South Dakota area. The measured average insolation in the plane of the collector

was 1,293 Btu/ft^2-day, 28 percent below the long-term average of 1,802 Btu/ft^2-day. Long-term environmental data are derived from data supplied by Reference Monthly Environmental Data for Systems in the National Solar Data Network, Department of Energy Report, SOLAR/0019-79/36.

C. System Thermal Performance

Collector - During the reporting period, a total of 41.37 million Btu of solar energy was measured in the plane of the collector array. The system collected 9.43 million Btu or 23 percent of the total available insolation. During the time the system was operating, a total of 28.61 million Btu was incident on the array. This represents an operational collector efficiency of 33 percent. A total of 0.40 million Btu of electrical energy was required to collect solar energy when the system was operating in the collection or storage modes.

Storage - Storage calculations show that 3.53 million Btu were delivered to storage during the reporting period and 2.68 million Btu were supplied from storage. Storage losses included 0.72 million Btu from the storage tank and an additional 0.77 million Btu from the collector loop-to-storage loop heat exchanger. A total of 1.34 million Btu was delivered to storage during periods when the storage loop pump P2 was off, apparently due to thermosiphon flow in the storage loop. A net decrease in stored energy of 0.13 million Btu was observed during the reporting period. Excluding the stored energy input due to thermosiphoning, the storage efficiency was 72 percent for the reporting period.

Space Heating Load - The space heating load for the reporting period was 1.65 million Btu. Solar energy supplied 1.44 million Btu of this load, which represents a heating solar fraction of 87 percent. An average building temperature of 71°F was maintained during the reporting period. There was no first stage heating from the collectors for this period and the entire solar contribution to the heating load was supplied from storage. Operating energy required to deliver solar energy to the heating load amounted to 0.10 million Btu. A total of 0.97 million Btu of solar energy was intentionally rejected by the heat rejection cooling tower.

Space Cooling Load - The space cooling load for the reporting period was 8.16 million Btu. Solar energy supplied 1.13 million Btu of this load, which represents a cooling solar fraction of 14 percent. Solar energy input to the absorption chillers amounted to 3.84 million Btu, resulting in a coefficient of performance (COP) for the solar cooling subsystem of 0.29. Auxiliary cooling provided by the vapor compression air conditioners amounted to 7.02 million Btu from the unit in the multizone air handler and 0.011 million Btu from the unit serving the observation room. Operating energy required to deliver solar energy to the cooling load amounted to 0.31 million Btu.

D. Observations

Review of scan level data for June 30 showed near freezing temperatures (measurements T502 and T552) at the inlet and outlet of the solar cooling coil which receives chilled water from the solar fired absorption chillers. With concern that these low temperatures could result in freezing and potential damage to the chillers, the Project Manager was notified who in turn notified site personnel. Data further showed a cessation of air flow through the observation room air handler where the solar cooling coil is located. Investigation by site personnel revealed a broken fan belt on the air handler fan. The fan belt was replaced and normal operation was restored on July 3, 1979, with no apparent damage to the system.

E. Energy Savings

The solar energy system at Mount Rushmore provided a savings of 2.39 million Btu of fossil fuel during the reporting period and a savings of 0.32 million Btu of electrical energy. This savings was realized at the cost of 0.40 million Btu of electrical operating energy for the Energy Collection and Storage Subsystem (ECSS).

III. ACTION STATUS

Sensor T400, which was cited as being in error in the monthly performance report for May, was replaced and recalibrated in early June and is now consistent with other temperature sensors in the collector loop.

Discrete signal D002 which indicates the status of valve V5 (through or bypass ARKLA units) appears to be non-functional. This problem will be corrected during a site visit scheduled for July 1979.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: JUNE,1979

SOLAR/2019-79/06

SITE/SYSTEM DESCRIPTION:
THE SOUTH DAKOTA SCHOOL OF MINES SOLAR SYSTEM IS DESIGNED TO CARRY ABOUT 50% OF THE HEATING LOAD AND ABOUT 40% OF THE COOLING LOAD. SECOND STAGE HEATING WILL BE PROVIDED BY A TWO STAGE FUEL OIL BURNER AND SECOND STAGE COOLING WILL BE PROVIDED BY A REFRIGERATION COMPRESSOR IN THE MULTIZONE UNIT AND A SINGLE ZONE 10-TON PACKAGE UNIT. THE SOLAR SYSTEM WILL UTILIZE 1692 SQ-FT OF DOUBLE COVER, SELECTIVE COATED, FLAT PLATE COLLECTORS, HEATING COILS IN THE MULTI-ZONE UNIT, THREE CHILLERS, COOLING TOWER, COOLING COILS IN THE SINGLE ZONE UNIT, AND 3000 GAL. WATER STORAGE TANK.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	41.371 MILLION BTU
	20686 BTU/SQ.FT.
COLLECTED SOLAR ENERGY	9.432 MILLION BTU
	4716 BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	62 DEGREES F
AVERAGE BUILDING TEMPERATURE	71 DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.13
ECSS OPERATING ENERGY	0.400 MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	0.810 MILLION BTU
TOTAL ENERGY CONSUMED	14.362 MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	N.A.	1.646	8.158	9.805 MILLION BTU
SOLAR FRACTION	N.A.	87	14	26 PERCENT
SOLAR ENERGY USED	N.A.	1.435	3.838	5.273 MILLION BTU
OPERATING ENERGY	N.A.	0.103	0.306	0.810 MILLION BTU
AUX. THERMAL ENERGY	N.A.	0.211	2.639	2.849 MILLION BTU
AUX. ELECTRIC FUEL	N.A.	N.A.	3.769	3.769 MILLION BTU
AUX. FOSSIL FUEL	N.A.	0.352	N.A.	0.352 MILLION BTU
ELECTRICAL SAVINGS	N.A.	-0.102	0.148	-0.354 MILLION BTU
FOSSIL SAVINGS	N.A.	2.392	N.A.	2.392 MILLION BTU

SYSTEM PERFORMANCE FACTOR: 0.628

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: JUNE,1979

SOLAR/2019-79/06

SITE/SYSTEM DESCRIPTION:
THE SOUTH DAKOTA SCHOOL OF MINES SOLAR SYSTEM IS DESIGNED TO CARRY ABOUT 50% OF THE HEATING LOAD AND ABOUT 40% OF THE COOLING LOAD. SECOND STAGE HEATING WILL BE PROVIDED BY A TWO STAGE FUEL OIL BURNER AND SECOND STAGE COOLING WILL BE PROVIDED BY A REFRIGERATION COMPRESSOR IN THE MULTIZONE UNIT AND A SINGLE ZONE 10-TON PACKAGE UNIT. THE SOLAR SYSTEM WILL UTILIZE 1692 SQ-FT OF DOUBLE COVER, SELECTIVE COATED, FLAT PLATE COLLECTORS, HEATING COILS IN THE MULTI-ZONE UNIT, THREE CHILLERS, COOLING TOWER, COOLING COILS IN THE SINGLE ZONE UNIT, AND 3000 GAL. WATER STORAGE TANK.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	43.647	GIGA JOULES
	234907	KJ/SQ.M.
COLLECTED SOLAR ENERGY	9.950	GIGA JOULES
	53553	KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	17	DEGREES C
AVERAGE BUILDING TEMPERATURE	22	DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	0.13	
ECSS OPERATING ENERGY	0.422	GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	0.854	GIGA JOULES
TOTAL ENERGY CONSUMED	15.152	GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	N.A.	1.727	8.607	10.344 GIGA JOULES
SOLAR FRACTION	N.A.	87	14	26 PERCENT
SOLAR ENERGY USED	N.A.	1.514	4.049	5.563 GIGA JOULES
OPERATING ENERGY	N.A.	0.109	0.323	0.854 GIGA JOULES
AUX. THERMAL ENG	N.A.	0.223	2.784	3.006 GIGA JOULES
AUX. ELECTRIC FUEL	N.A.	N.A.	3.977	3.977 GIGA JOULES
AUX. FOSSIL FUEL	N.A.	0.372	N.A.	0.372 GIGA JOULES
ELECTRICAL SAVINGS	N.A.	-0.108	0.156	-0.374 GIGA JOULES
FOSSIL SAVINGS	N.A.	2.524	N.A.	2.524 GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 0.628

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28,1978, SOLAR/0004-78/18

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: JUNE,1979

SOLAR/2019-79/06

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	@	@	@	@	@	@	@
2	@	@	@	@	@	@	@
3	@	@	@	@	@	@	@
4	@	@	@	@	@	@	@
5	@	@	@	@	@	@	@
6	@	@	@	@	@	@	@
7	@	@	@	@	@	@	@
8	@	@	@	@	@	@	@
9	@	@	@	@	@	@	@
10	@	@	@	@	@	@	@
11	@	@	@	@	@	@	@
12	@	@	@	@	@	@	@
13	@	@	@	@	@	@	@
14	0.000	56	0.000	@	0.000	0.000	0.000
15	3.009	61	0.141	@	0.033	0.000	0.047
16	1.517	55	0.000	@	0.004	0.000	0.000
17	0.169	48	0.000	@	0.000	0.000	0.000
18	0.707	51	0.162	@	0.002	0.000	0.229
19	0.685	50	0.065	@	0.003	0.000	0.095
20	3.572	62	0.251	@	0.050	0.000	0.070
21	3.722	65	0.473	@	0.037	0.000	0.127
22	3.351	64	0.449	@	0.033	0.000	0.134
23	2.110	59	0.085	@	0.021	0.000	0.041
24	2.294	63	0.209	@	0.014	0.000	0.091
25	3.132	73	0.552	@	0.026	0.133	0.176
26	2.486	66	0.519	@	0.021	0.016	0.209
27	3.268	67	0.596	@	0.023	0.285	0.182
28	3.221	71	0.457	@	0.037	0.029	0.142
29	4.174	72	0.337	@	0.047	0.334	0.081
30	3.953	77	0.976	@	0.038	0.171	0.247
SUM	41.371	-	5.273	N.A.	0.400	0.967	-
AVG	1.379	62	0.176	N.A.	0.013	0.032	0.127
NBS ID	Q001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD SOLAR/2019-79/06
REPORT PERIOD: JUNE,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	@	@	@	@	@
2	@	@	@	@	@
3	@	@	@	@	@
4	@	@	@	@	@
5	@	@	@	@	@
6	@	@	@	@	@
7	@	@	@	@	@
8	@	@	@	@	@
9	@	@	@	@	@
10	@	@	@	@	@
11	@	@	@	@	@
12	@	@	@	@	@
13	@	@	@	@	@
14	0.000	0.000	0.000	@	0.000
15	3.009	2.483	0.918	70	0.305
16	1.517	0.248	0.132	60	0.087
17	0.169	0.000	0.000	49	0.000
18	0.707	0.016	-0.064	53	-0.090
19	0.685	0.054	-0.023	47	-0.034
20	3.572	3.125	1.175	70	0.329
21	3.722	3.218	1.159	76	0.311
22	3.351	2.403	0.686	76	0.205
23	2.110	1.103	0.460	63	0.218
24	2.294	1.191	0.118	72	0.051
25	3.132	2.111	0.955	89	0.305
26	2.486	1.685	0.410	72	0.165
27	3.268	2.182	0.996	83	0.305
28	3.221	2.300	0.663	81	0.206
29	4.174	3.594	1.022	84	0.245
30	3.953	2.898	0.825	86	0.209
SUM	41.371	28.611	9.432	-	-
AVG	1.379	0.954	0.314	71	0.228
NBSIO	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD SOLAR/2019-79/06
REPORT PERIOD: JUNE,1979

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	@	@	@	@	@
2	@	@	@	@	@
3	@	@	@	@	@
4	@	@	@	@	@
5	@	@	@	@	@
6	@	@	@	@	@
7	@	@	@	@	@
8	@	@	@	@	@
9	@	@	@	@	@
10	@	@	@	@	@
11	@	@	@	@	@
12	@	@	@	@	@
13	@	@	@	@	@
14	0.000	0.000	-0.002	122	1.000
15	0.623	0.000	0.589	135	0.946
16	0.036	0.000	-0.051	145	-1.427
17	0.000	0.000	-0.105	142	1.000
18	0.000	0.275	-0.401	127	1.000
19	0.000	0.158	-0.226	117	1.000
20	0.312	0.282	0.542	127	0.910
21	0.734	0.244	0.357	138	0.819
22	0.286	0.138	0.074	151	0.741
23	0.251	0.198	-0.004	152	0.772
24	0.208	0.077	-0.014	153	0.305
25	0.013	0.152	-0.164	153	-0.868
26	0.023	0.295	-0.350	132	-2.439
27	0.123	0.000	0.066	134	0.539
28	0.155	0.130	0.069	140	1.285
29	0.171	0.277	-0.081	137	1.151
30	-0.002	0.447	-0.432	120	-6.226
SUM	3.533	2.679	-0.131	-	-
AVG	0.118	0.089	-0.004	137	0.721
NBS ID	Q200	Q201	Q202		N108

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE HEATING SUBSYSTEM

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: JUNE,1979

SOLAR/2019-79/06

DAY OF MON.	SPACE HEATING LOAD MILLION BTU	SOLAR FR.OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG TEMP DEG. F	AMB TEMP DEG. F
1	@	@	@	@	@	@	@	@	@	@	@
2	@	@	@	@	@	@	@	@	@	@	@
3	@	@	@	@	@	@	@	@	@	@	@
4	@	@	@	@	@	@	@	@	@	@	@
5	@	@	@	@	@	@	@	@	@	@	@
6	@	@	@	@	@	@	@	@	@	@	@
7	@	@	@	@	@	@	@	@	@	@	@
8	@	@	@	@	@	@	@	@	@	@	@
9	@	@	@	@	@	@	@	@	@	@	@
10	@	@	@	@	@	@	@	@	@	@	@
11	@	@	@	@	@	@	@	@	@	@	@
12	@	@	@	@	@	@	@	@	@	@	@
13	@	@	@	@	@	@	@	@	@	@	@
14	0.000	0	0.000	0.000	0.000	@	0.000	0.000	0.000	71	56
15	0.002	0	0.000	0.000	0.002	@	0.003	0.000	0.000	71	61
16	0.000	0	0.000	0.000	0.000	@	0.000	0.000	0.000	71	55
17	0.000	0	0.000	0.000	0.000	@	0.000	0.000	0.000	69	48
18	0.175	93	0.162	0.014	0.012	@	0.021	-0.014	0.270	70	51
19	0.065	100	0.065	0.008	0.000	@	0.000	-0.008	0.109	69	50
20	0.247	83	0.206	0.014	0.041	@	0.069	-0.014	0.343	71	62
21	0.097	98	0.096	0.010	0.002	@	0.004	-0.010	0.160	71	65
22	0.081	98	0.080	0.004	0.002	@	0.003	-0.004	0.133	71	64
23	0.085	100	0.085	0.004	0.000	@	0.000	-0.004	0.142	72	59
24	0.168	13	0.022	0.001	0.146	@	0.244	-0.001	0.036	72	63
25	0.074	97	0.072	0.004	0.002	@	0.004	-0.004	0.120	70	73
26	0.216	99	0.214	0.012	0.002	@	0.004	-0.012	0.356	70	56
27	0.001	0	0.000	0.000	0.001	@	0.002	0.000	0.000	71	67
28	0.086	100	0.086	0.005	0.000	@	0.000	-0.005	0.143	72	71
29	0.110	100	0.110	0.008	0.000	@	0.000	-0.008	0.184	73	72
30	0.238	100	0.238	0.018	0.000	@	0.000	-0.018	0.397	72	77
SUM	1.646	-	1.435	0.103	0.211	N.A.	0.352	-0.102	2.392	-	-
AVG	0.055	87	0.048	0.003	0.007	N.A.	0.012	-0.003	0.080	71	62
NBS	Q402	N400	Q400	Q403	Q401		Q410	Q415	Q417	N406	N113

* DENOTES UNAVAILABLE DATA.
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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE COOLING SUBSYSTEM

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: JUNE,1979

SOLAR/2019-79/06

DAY OF MON.	SPACE COOLING LOAD MILLION BTU	SOLAR FR.OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG DRY BULB TEMP F	AMB TEMP DEG F
1	@	@	@	@	@	@	@	@	@	@	@
2	@	@	@	@	@	@	@	@	@	@	@
3	@	@	@	@	@	@	@	@	@	@	@
4	@	@	@	@	@	@	@	@	@	@	@
5	@	@	@	@	@	@	@	@	@	@	@
6	@	@	@	@	@	@	@	@	@	@	@
7	@	@	@	@	@	@	@	@	@	@	@
8	@	@	@	@	@	@	@	@	@	@	@
9	@	@	@	@	@	@	@	@	@	@	@
10	@	@	@	@	@	@	@	@	@	@	@
11	@	@	@	@	@	@	@	@	@	@	@
12	@	@	@	@	@	@	@	@	@	@	@
13	@	@	@	@	@	@	@	@	@	@	@
14	0.000	0	0.000	0.000	0.000	0.000	@	0.000	@	71	56
15	0.400	15	0.141	0.015	0.127	0.181	@	0.009	@	71	61
16	0.000	0	0.000	0.000	0.000	0.000	@	0.000	@	71	55
17	0.000	0	0.000	0.000	0.000	0.000	@	0.000	@	69	48
18	0.000	0	0.000	0.000	0.000	0.000	@	0.000	@	70	51
19	0.000	0	0.000	0.000	0.000	0.000	@	0.000	@	69	50
20	0.274	-0	0.045	0.003	0.113	0.161	@	-0.004	@	71	62
21	0.560	28	0.378	0.036	0.144	0.205	@	0.028	@	71	65
22	0.549	32	0.369	0.035	0.146	0.209	@	0.036	@	71	64
23	0.000	0	0.000	0.000	0.000	0.000	@	0.000	@	72	66
24	0.273	29	0.187	0.016	0.074	0.106	@	0.016	@	72	63
25	1.145	17	0.480	0.041	0.329	0.470	@	0.035	@	70	73
26	1.188	8	0.305	0.025	0.430	0.615	@	0.015	@	70	66
27	0.586	25	0.596	0.033	0.184	0.263	@	0.025	@	71	67
28	0.971	17	0.372	0.035	0.296	0.423	@	0.030	@	72	71
29	0.852	6	0.227	0.018	0.316	0.451	@	0.005	@	73	72
30	1.359	0	0.738	0.049	0.479	0.685	@	-0.047	@	72	77
SUM	8.158	-	3.838	0.306	2.639	3.769	N.A.	0.148	N.A.	-	-
AVG	0.272	14	0.128	0.010	0.087	0.126	N.A.	0.005	N.A.	71	62
NBS	Q502	N500	Q500	Q503	Q501		Q508	Q512	Q514	N406	N113

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: JUNE,1979

SOLAR/2019-79/06

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	@	@	@	@	@	@	@
2	@	@	@	@	@	@	@
3	@	@	@	@	@	@	@
4	@	@	@	@	@	@	@
5	@	@	@	@	@	@	@
6	@	@	@	@	@	@	@
7	@	@	@	@	@	@	@
8	@	@	@	@	@	@	@
9	@	@	@	@	@	@	@
10	@	@	@	@	@	@	@
11	@	@	@	@	@	@	@
12	@	@	@	@	@	@	@
13	@	@	@	@	@	@	@
14	0	@	56	@	@	@	@
15	1504	@	61	70	@	@	@
16	759	@	55	60	@	@	@
17	85	@	48	49	@	@	@
18	354	@	51	53	@	@	@
19	343	@	50	47	@	@	@
20	1786	@	62	70	@	@	@
21	1861	@	65	76	@	@	@
22	1676	@	64	76	@	@	@
23	1055	@	59	63	@	@	@
24	1147	@	63	72	@	@	@
25	1566	@	73	89	@	@	@
26	1243	@	66	72	@	@	@
27	1634	@	67	83	@	@	@
28	1611	@	71	81	@	@	@
29	2087	@	72	84	@	@	@
30	1976	@	77	86	@	@	@
SUM	20696	N.A.	-	-	-	-	-
AVG	690	N.A.	62	71	N.A.	N.A.	N.A.
NBS ID	Q001		N113			N115	N114

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
THERMODYNAMIC CONVERSION EQUIPMENT

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD SOLAR/2019-79/06
REPORT PERIOD: JUNE,1979

DAY OF MONTH	EQUIPMENT LOAD MILLION BTU	THERMAL ENERGY INPUT MILLION BTU	OPERATING ENERGY MILLION BTU	ENERGY REJECTED MILLION BTU	COEFFICIENT OF PERFORMANCE (SEE NOTE)
1	@	@	@	@	@
2	@	@	@	@	@
3	@	@	@	@	@
4	@	@	@	@	@
5	@	@	@	@	@
6	@	@	@	@	@
7	@	@	@	@	@
8	@	@	@	@	@
9	@	@	@	@	@
10	@	@	@	@	@
11	@	@	@	@	@
12	@	@	@	@	@
13	@	@	@	@	@
14	0.000	0.000	0.000	0.000	0.000
15	0.061	0.141	0.015	0.000	0.431
16	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000
20	-0.001	0.045	0.003	0.000	-0.023
21	0.159	0.378	0.036	0.000	0.420
22	0.176	0.369	0.034	0.000	0.476
23	0.000	0.000	0.000	0.000	0.000
24	0.080	0.187	0.016	0.002	0.429
25	0.189	0.480	0.040	0.000	0.394
26	0.100	0.305	0.025	0.428	0.329
27	0.145	0.596	0.032	0.582	0.243
28	0.162	0.372	0.025	0.586	0.436
29	0.050	0.227	0.017	0.372	0.236
30	0.006	0.738	0.049	0.916	0.008
SUM	1.130	3.838	0.304	2.887	0.294
AVG	0.038	0.128	0.010	0.096	0.010

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